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A CONTRIBUTION TO THE KNOWLEDGE OF *MICROMALTHUS DEBILIS* LeC. (COLEOPTERA)

By J. A. Pringle, M.Sc.

(*Department of Zoology, University of the Witwatersrand, Johannesburg.*)

With a note by Nellie F. Paterson, Ph.D., M.Sc.

(Read 1st June, 1938.)

With Plate 1 and Four Text-Figures.

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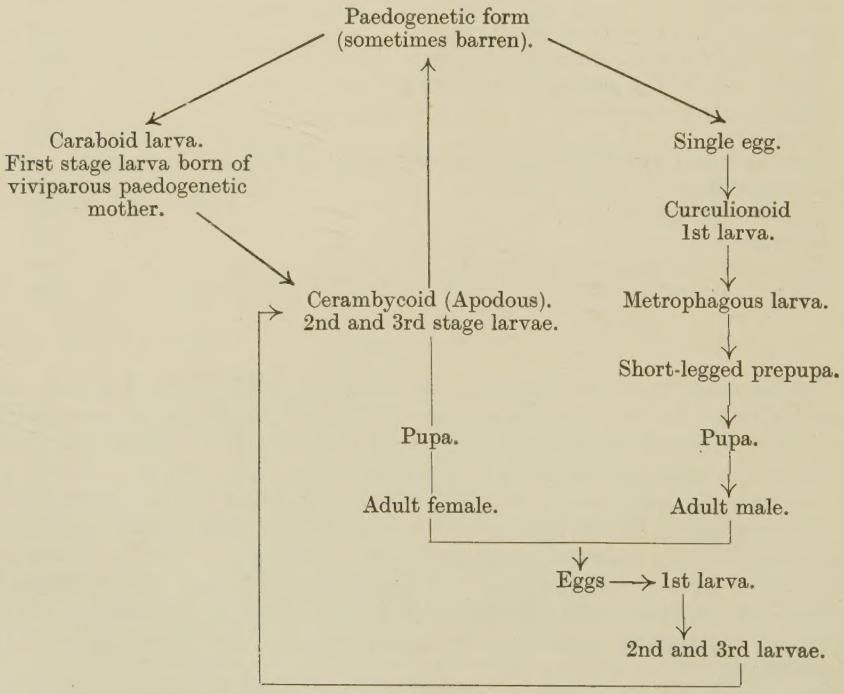
Introduction.

Micromalthus was first named and described in 1878 by LeConte, who referred it to the Lymexylonidae on account of the resemblance of the antennae and coxae to those of *Hylecoetus*. Although Hubbard gave a brief description in 1878 of the cerambycoid larva of the new species, *Micromalthus debilis*, the life-cycle remained unknown until 1913, when Barber was able to piece together the various stages in the life history by isolation experiments, and his publication is recognised as the classical contribution to the subject. Shortly afterwards Caillol (1914) gave a critical account of Barber's contribution, and although he had made no personal observations on the subject himself, put forward several interesting suggestions regarding the interpretations and homologies of the various stages.

There are two further notable contributions towards the knowledge of this interesting genus. Böving and Craighead in their work on Coleopterous larvae (1931) place *Micromalthus* in the superfamily Cupesoidea, which also includes the family Cupesidae, while van Emden (1932), basing his conclusions on the wing venation, discussed the Adephagid relationships of *Micromalthus*, and considered that it is closely allied to the Cupediformia.

Life cycle.

In 1913, Barber published the first paper dealing with the life history of *Micromalthus debilis*. On the 3rd January, 1913, he was given part of a pine log found near Natural Bridge, Kentucky, which contained only cerambycoid larvae. On the 8th February, 1913, on opening the wood, he found the colony maturing into paedogenetic individuals, one of which had already given birth to twenty-one larvae, and the latter were busy devouring the remains of their paedogenetic mother. The larvae, to which he applied the term "caraboid," were placed together in a separate cell with some chips of decaying wood. This wood was examined on 1st July of the same year, and it was found that five of the larvae had died, and of the remaining sixteen, seven were fully-fed cerambycoid larvae, four were in the paedogenetic stage, two further paedogenetic forms had given birth to caraboid larvae, one had metamorphosed into a pupa and two paedogenetic individuals had each produced an egg, which was still adhering to the side of the parent body. The pupa subsequently developed into an adult female, and the transformations from the parthenogenetic egg were most complicated. One egg hatched into a curculionoid larva, which, placing its head into the vulva of the mother, fed on the intestinal contents. It later changed into a metrophagous larva with stumpy three-segmented legs, and eventually pupated. This pupa died, but it was assumed that from it an adult male would emerge.



From this somewhat fragmentary information, Barber pieced together the life-cycle and his conclusions were as follows: The paedogenetic larva gives birth to the caraboid larvae which, after moulting, change into cerambycoid larvae. The latter moult several times and the mature larvae may follow one of four courses.

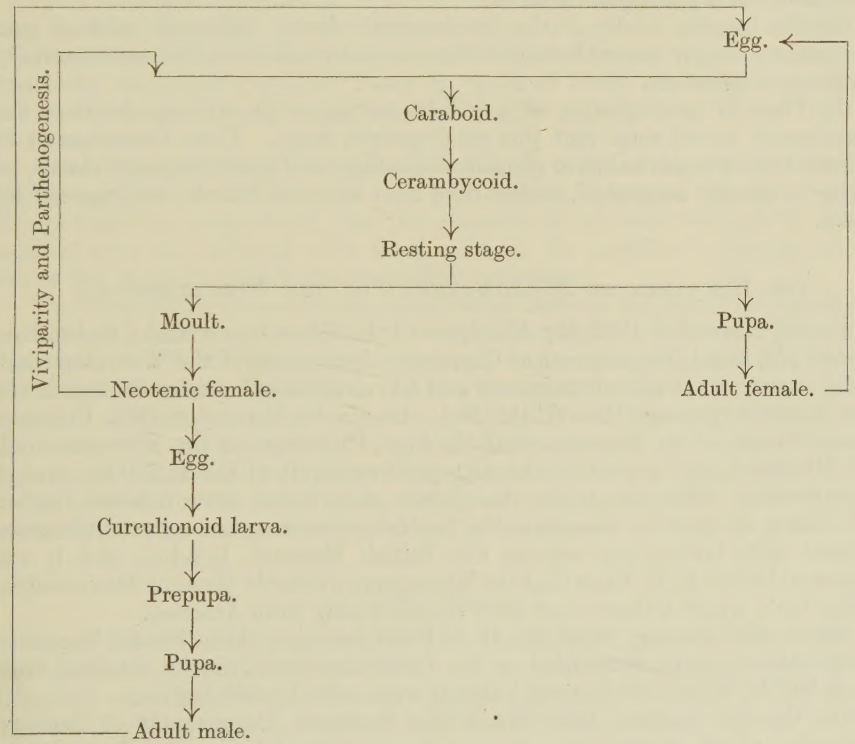
(1) Each may pupate and emerge as an adult female.
(2) Each may moult into a paedogenetic individual which gives birth to caraboid larvae.
(3) Each may produce barren paedogenetic larvae.
(4) Each may produce the oviparous paedogenetic larvae.

This latter unioviparous larva produces an egg, from which hatches a curculionoid larva. A prepupal phase precedes pupation, and finally the adult male emerges.

Barber succeeded in following all the stages up to the prepupal stage, and assumed that the pupa resulting therefrom would give rise to an adult male. He completed the life-cycle by supposing that the fertilised female would produce several large eggs which would develop into cerambycoid larvae.

The life-cycle of *Micromalthus* according to Barber (1913) is shown on p. 272.

In his criticism of the above life-history, Caillol (1914) suggested that the caraboid stage is merely a triungulin larva similar to that of the MELOIDAE and that the paedogenetic larva should be regarded as a degenerate, parthenogenetic adult, which he preferred to call a neotenic female. His interpretation therefore of the life-cycle is as follows :



Barber mentioned that the caraboid larvae are migratory, but dispersal at this stage could only occur if the cell of the paedogenetic mother were accidentally opened, or if the larvae happen to burrow to the surface, which is hardly possible if they are located some distance from the surface of the timber. Their long slender legs, by means of which they move with extreme rapidity when liberated from the wood, may possibly assist in beginning a new burrow.

x 2

As previously mentioned, Caillol (1914) stated that as the development is attended by a hypermetamorphosis similar to that of the MELOIDAE, the caraboid larva should be called a triungulin. Barber's reason for designating this the caraboid larva was that each leg is five-segmented and terminates in a pair of claws, but it is noticeable that this primitive Carabid characteristic is also present in the triungulin larva of the MELOIDAE. The larva of *Micromalthus* lacks the most conspicuous characteristics of the larvae of the CARABIDAE, namely, the elongate anal cerci and antennae, and I consider that Caillol's remarks are fully justified and that this larval stage is comparable with a triungulin.

Caillol further considered that the paedogenetic larva is a degenerate, deälate, parthenogenetic female. He therefore maintained that there are two females—the one mentioned above and the normal winged sexual female. Admittedly this larva is degenerate and wingless, but I cannot find justification for calling it a parthenogenetic female for the following reasons :

(1) Normally, the development of embryos within the adult insect, even if degenerate, only begins when the adult is fully formed, but in *Micromalthus* the larvae are already partially developed in the last cerambycoid larval stage. The white larva which succeeds the mature cerambycoid stage, must therefore be regarded as a paedogenetic larva.

(2) The mouth parts of the paedogenetic larva, although reduced and functionless, closely resemble those of the cerambycoid larva and are essentially larviform in structure.

(3) There is no indication of a definite resting or pupal stage between the cerambycoid larval stage and this paedogenetic stage. These factors seem to indicate that it is advisable to consider this stage as a parthenogenetic larva, as Barber originally suggested, rather than as a neotenic female, as proposed by Caillol.

THE DISCOVERY OF *MICROMALTHUS* ON THE WITWATERSRAND.

During November 1932, Mr. Matthews of the Mines Department, Germiston, advised Mr. Segal, Department of Chemistry, University of the Witwatersrand, of the occurrence of numerous insects and larvae in decaying mine timbers in the East Rand Proprietary Mine (E.R.P.M.). On the 1st December, 1932, Professor van der Horst, of the Department of Zoology, University of the Witwatersrand, and Mr. Segal paid a visit to the Angelo Deep Shaft of the E.R.P.M., and at approximately 6000 feet below the surface they found some infested timber. The insects in question were found to be *Holoparamecus*, but some of the wood infested with larvae was sent to the British Museum, London, and it was suggested by Dr. K. G. Blair that the larvae were probably those of *Micromalthus debilis* LeC., which hitherto had been recorded only from America.

On the 30th January, 1934, Mr. H. A. Read, manager of the Timber Exchange Yard, Johannesburg, forwarded to the University some timber obtained from the E.R.P.M. which was heavily infected with cerambycoid larvae.

On the 7th August, 1934, Dr. Nellie Paterson, Department of Zoology, University of the Witwatersrand, gave me the remaining material which was originally obtained from the E.R.P.M. This had been kept in a closed flask and a few cerambycoid larvae were found to be still alive in the middle of the wood.

On the 14th August, 1934, Miss R. Lurie, Department of Botany, University of the Witwatersrand, who is working on the preservation of mine timbers against fungal infections, kindly brought in some infested timber from No. 5 Shaft,

Crown Mines, Johannesburg. This material was carefully examined by Dr. Paterson and me, and several pupae and seven adults were obtained. Two of the latter were preserved and retained by us, while five were despatched to Dr. Blair of the British Museum and confirmed as females of *Micromalthus debilis* LeC. In addition to these adults and pupae, there were numerous cerambycoid larvae, as well as some white larvae which were quite inactive.

On the 26th August, 1934, Dr. Paterson obtained some infested *Eucalyptus globulus* Labill. from the Chris Shaft, Robinson Deep Mine. This timber was heavily infested with cerambycoid larvae and one of the white or paedogenetic larvae was discovered in a cell in the process of giving birth to a number of triungulin larvae.

Between August and November, 1934, I visited, or obtained material from, most of the mines along the central Reef area, particularly from the Robinson Deep, East Rand Proprietary, Springs and Crown Mines, and found that a certain amount of timber in all these mines is attacked by *Micromalthus*.

Timber infestation.

From personal observations it would seem that no type of timber, if placed in a sufficiently damp situation in the mine, is resistant to the attacks of *Micromalthus*. The timbers most extensively used in the mines are those of *Acacia* sp., *Eucalyptus* sp., and *Pinus* sp., most of which are treated, but if the conditions are sufficiently moist all these suffer equally from the ravages of *Micromalthus*.

It was observed that the timbers most heavily infested occurred in the older, badly ventilated shafts and that they had been underground for several years. It must also be remembered that the majority of timbers attacked by *Micromalthus* were also infested with fungi, and by the combined activities of the larvae and fungi the wood was practically pulverised.

The temperature in most of the mines varies between 88° and 93° F., according to the depth below the surface and to the ventilation in the shaft. The high temperature of 93° F. was recorded in an old worked-out drive at level 23 in the Turf Shaft, Robinson Deep Mine. In this locality there was also a great deal of stagnant or slowly running water, and judging by the degree of infestation of the timbers the conditions appear to be ideal for the insect. In many instances, the uprights 12 inches in diameter were completely decayed and pulverised.

In most shafts the temperature was lower, ranging from 88° to 90° F., and as the ventilation was good, the infestation was lighter.

Material.

From different levels in each of the mines visited, material was collected from infested supports in the drives, and as such timber was decaying, no difficulty was experienced in breaking off pieces by hand. In some cases portions of old logs, which had been removed from some of the stopes, were also sawn up and taken to the laboratory.

The material was always subjected to careful examination on the same day, by sorting out the pulverised wood, and by breaking up the larger pieces into fragments. In this way for over a period of three months a large amount of infested timber was examined from different parts of various mines, and it seems improbable that any of the stages of development could have been overlooked.

In spite of this diligent search, in which Professor van der Horst and Dr.

Paterson also assisted, no males or their larval predecessors were found, although pupae and adult females occurred in some of the timbers examined.

Some of the infested timber was also kept in an incubator at a temperature of 90° F. It was placed in a basin containing water, and a small quantity of water was added each day, so that not only was the air in the incubator saturated with moisture, but some of the water also permeated through the wood.

Numerous isolation experiments were also carried out as follows: The larvae, which had been isolated from the timber, and were under observation, were placed in petri-dishes, lined with moist blotting-paper, and covered with chips of decayed and pulverised wood.

Difficulty was experienced in determining the length of the instars of the cerambycoid larvae, but this was partially overcome by commencing observations on triungulin larvae, which had recently been produced by a paedogenetic form. These triungulin larvae, soon after isolation in the petri-dishes as described above, migrated into the wood, which was then examined once a week, while those remaining were allowed to continue their development undisturbed. It had previously been noticed that the removal of the cerambycoid stage from its channel checked the normal development and often resulted in the death of the larva. It was soon found, however, that there was a great variation in the rate of development of the larvae under observation. This was exemplified by the fact that at the end of the first week some of the larvae had changed into the first-stage cerambycoid larvae, while others were still in the triungulin stage. After three weeks some larvae had changed into the second-stage cerambycoid while others were still in the first-stage cerambycoid. Barber also observed similar developmental variations in his specimens. He found that certain larvae tend to lag behind others in their development, in spite of the fact that they were all subjected to the same conditions of temperature, humidity and environment.

Further investigations of the possible causes of these variations in the rate of development may disclose certain factors influencing the future life of the larvae, and perhaps it may be possible to distinguish at an early stage those destined to become female pupae, paedogenetic forms, or male pupae respectively.

The above may also throw some light on an interesting point raised by Barber, who noticed that the cells of the pupa and oviparous paedogenetic larva were less than 3 mm. apart in wood of the same state of decay. I also found pupae which would later emerge as females, and viviparous paedogenetic larvae located close to each other in the same wood, but at present can offer no suggestions as to the reason for their proximity.

Occurrence.

The occurrence of *Micromalthus* in the gold mines of the Transvaal suggests that possibly this beetle has a far wider distribution than has been suspected so far. The first described adults were from North America, and Barber (1913) mentioned in his paper that he had obtained specimens from Kentucky, Michigan and Virginia.

The occurrence of *Micromalthus* in the Transvaal presents at least two possibilities which may account for its presence in the mines. (1) When the gold mines were first started some fifty years ago, a large quantity of pitch pine was imported from North America for use in the mines. It seems quite probable that some of this timber may have been infested, and thus the infestation was started underground in certain mines. (2) There is also the possibility that

Micromalthus may occur in some of the moist forest areas in South Africa, such as those in the George and Knysna districts; so far it has not been discovered there. South African timber is now being utilised extensively in the mines, and if *Micromalthus* does occur in these forest areas, it seems quite credible that some infested timber may have been transported to the mines.

Should *Micromalthus* be discovered elsewhere in South Africa, it would suggest that this is the source of the mine infestation, since: (1) The females sent to Dr. Blair were stated by him to be specimens of *Micromalthus debilis* LeC., but that they had one more abdominal segment than those described by LeConte in 1878. (2) Barber made no reference to the fact that moisture was essential for the welfare of the larvae of the American species, but it is noticeable that those from the mines of the Transvaal remain dormant if in desiccated wood. The high temperature in the mines may be conducive to a more rapid development but it is not absolutely necessary, while moisture, on the other hand, is essential for their welfare. It hardly seems possible that two such changes could have taken place in the North American species since its importation into South Africa less than fifty years ago.

The Anatomy of the Early Stages of *Micromalthus*.

In the descriptions which follow differences of structure are noted, and possibly indicate that this is a new variety of a somewhat rare insect.

Morphology of the Triungulin Larva.

The larva (fig. 1, a) measures 1·75 mm. in length and 0·25 mm. in width. It is white in colour and of the campodeiform type, with three pairs of well-developed thoracic legs.

Head.

The head (fig. 1, b) is dorso-ventrally compressed and is broader than long, widening out posteriorly. The epicranial suture (e.s.) extends from the posterior margin of the head to the clypeal suture, at which point it broadens slightly but does not fork as indicated by Böving and Craighead (1931). The occipital foramen is only slightly smaller than the head capsule. The clypeus (cl.) is a membranous transverse sclerite. There are numerous setae symmetrically arranged over the head capsule. Ocelli are absent.

Head appendages.

Each four-segmented antenna (ant., fig. 1, b) is located on the antero-lateral border of the head. The first segment (1 fig. 1, d) is broader than long and bears a sensory pore. Arising from the second segment (2) are both the third (3) and the fourth (4) segments. The third segment is elongate and terminates in a long sensory spine. The fourth segment is shorter than the third and situated ventro-laterally to it. A single short seta is located on the dorsal surface of the second segment.

Mouth parts.

The labrum (lr., fig. 1, b) is an almost semicircular sclerite, with four setae overhanging its anterior margin and a pair situated in the posterior half. There are several downwardly directed setae on the ventral surface of the labrum.

Each mandible (fig. 1, c) is a heavily-sclerotised tridentate structure. The median tooth is larger and more lateral in position than the dorsal and ventral

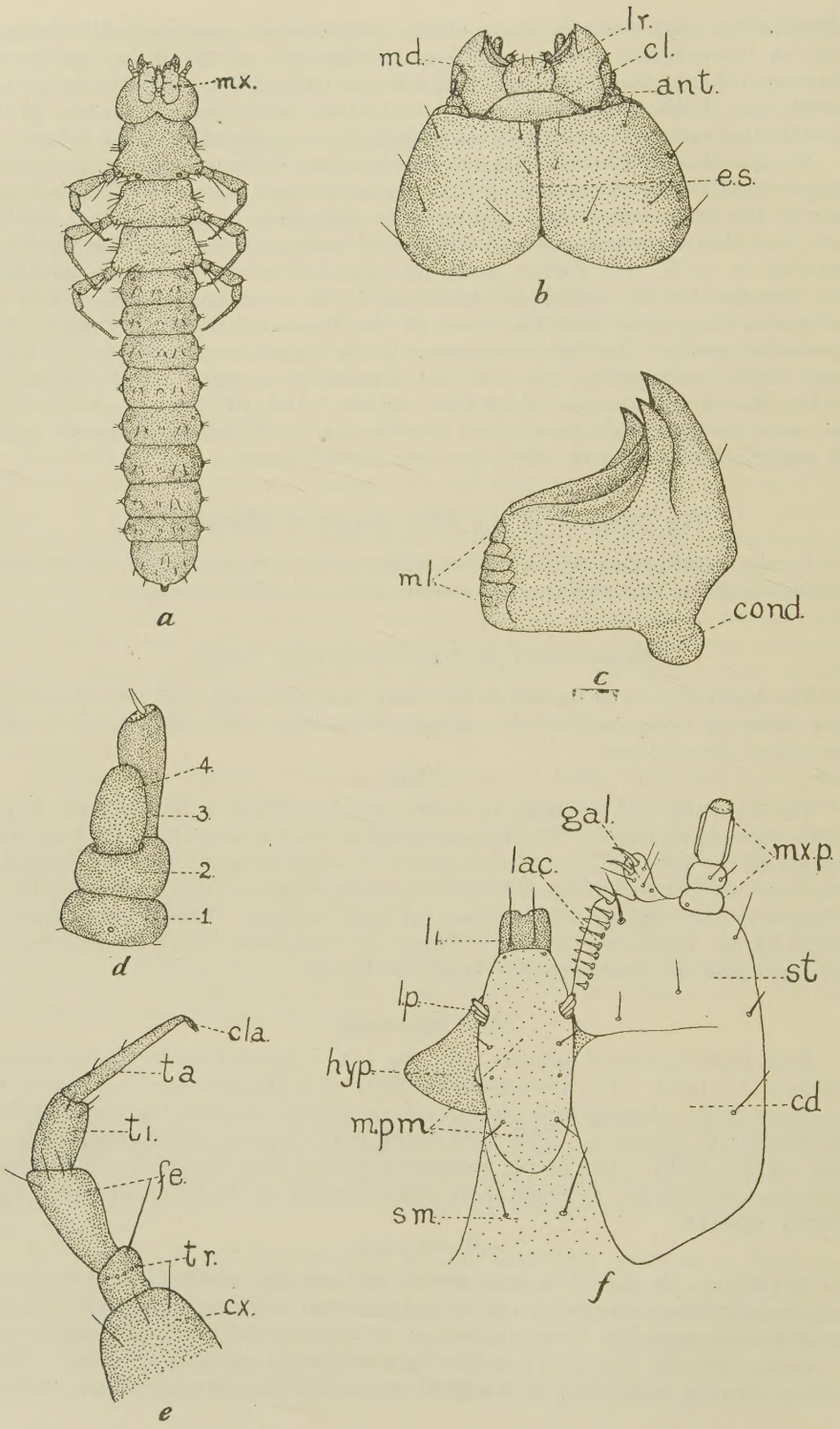


FIG. 1.—Triungulin larva of *Micromalthus*. *a*. triungulin larva, ventral view; *b*. head, dorsal view; *c*. mandible, ventral view; *d*. right antenna, ventral view; *e*. prothoracic leg; *f*. left maxilla and labrum (right maxilla removed to show part of the hypopharynx).

teeth. Each tooth bears a groove on the inner surface which extends to the upper portion of the molar area (ml.). The latter is located medially and has a slightly serrated surface.

Maxillae.

Each maxilla (mx., fig. 1, a) is a large sclerite and extends more than halfway along the ventral surface of the head. The cardo (cd., fig. 6) is feebly sclerotised, almost rectangular in shape, with a single lateral seta. The stipes (st.), which bears five definitely-arranged setae, is fused along the greater portion of its posterior margin to the cardo. The galea (gal.) is an elongate finger-like projection divided off from the stipes. It bears two stout spurs, three setae and one sensory pore. The lacinia (lac.) is located along the medial border of the stipes. It comprises one stout spur on the anterior margin from which two rows of smaller spurs diverge posteriorly. The dorsal row contains seven and the ventral eight spurs. The palp (mx. p.) is a three-segmented structure, in which the first segment bears a sensory pore, the second a pair of setae and the third is elongate, terminating in a number of sensory papillae.

Labium.

In the labium (fig. 1, f), the submentum (sm.) is membranous and lies between, and posterior to, the cardines, and bears a pair of elongate setae. The mentum and prementum (m. pm.) are fused into an elongate membranous area lying between the maxillae, the labial palps (l.p.) being located laterally in the anterior half of this area. Each palp (l.p.) is three-segmented, but the segments are in juxtaposition and only the anterior is furnished with terminal sensory papillae. Arranged symmetrically on the fused mentum and prementum are two pairs of setae and two sensory pores.

The ligula (li., fig. 1, f) is a sclerotised elongate structure which projects anteriorly and bears two setae on the lower surface. The premental area does not reach to the anterior edge of the ligula on the ventral surface. Distally in the mouth cavity, the ligula expands into a triangular sclerotised hypopharynx (hyp.) which has a median triangular aperture. As the hypopharynx of the triungulin stage resembles that of the cerambycoid, a detailed description will be given under that of the latter larva.

Thorax.

The thoracic segments are subcylindrical, each bearing a pair of elongate legs. The prothorax is slightly more elongate than either the meso- or metathorax. Each segment has a similar and definite arrangement of the setae. A pair of spiracles is located latero-ventrally on the prothorax towards the posterior margin.

Legs.

Each of the legs (fig. 1, e) is five-segmented and similar in appearance. The articulation of the coxal segment (cx.) is not distinctly demarcated from the body. This segment is large and furnished with several setae. The trochanter (tr.) is a small cylindrical segment bearing a single elongate seta. The femur (fe.) broadens considerably towards its distal border, where three setae are situated. The tibia (ti.) is cylindrical and slightly longer than the trochanter. The tarsal segment (ta.) is elongate and tapers gradually to the distal end, where it is furnished with two short claws. This compares very closely with that figured by Böving and Craighead (1931).

Abdomen.

The abdomen is elongate and cylindrical, except the ninth or last segment, which is conical and dorso-ventrally compressed. The first eight segments are transverse and subequal, and each bears several setae which are arranged on a definite plan. On the lateral surface of each segment is a small protuberance which is furnished with a pair of setae. Each of these segments bears a pair of spiracles which is situated on the ventral surface towards the anterior margin. The terminal segment is furnished with a larger dorsal, and a smaller ventral anal plate, which are palmate and project slightly. The anus opens between these plates.

Morphology of the Cerambycoid Larva.

The larva (fig. 2, a), which is white in colour, is elongate and cylindrical. The intestine, however, is visible through the dorsal surface of the thin abdominal wall as a dark band. The measurements of the instars are as follows: first larval instar: length 2·5 to 3 mm., head width 0·38 mm.; second larval instar: length 4 to 4·5 mm., head width 0·51 mm.; third larval instar: length 5·5 mm., head width 0·69 mm.

Head.

The head-capsule (fig. 2, d) closely resembles that of the triungulin larva, except that it is not quite so elongate. It is similar to that figured by Hubbard (1878) and Böving and Craighead (1931), but there are some differences in the chaetotaxy. The clypeus (cl.) is similar to that of the triungulin larva.

Head appendages.

Each antenna (ant., fig. 2, d) bears a very close resemblance to that of the triungulin larva, except that anteriorly on the second segment there are two sensory pores and two small setae—one dorsal and one ventral. The terminal spine of the third segment is comparatively shorter than that of the triungulin larva. The fourth segment is always laterally directed, while Hubbard (1878) and Böving and Craighead (1931) show that in the American species it is medial in position. According to their figures, the terminal spine is much more elongate than in the South African specimens.

Mouth parts.

The labrum (lr., fig. 2, d) is similar to that of the triungulin larva, except that the ventral setae are more strongly developed. Each mandible (fig. 2, c) closely resembles that of the triungulin larva, but the molar surface (ml.) is better developed and consists of fourteen transverse serrations. Böving and Craighead (1931) figure the mandible as a structure having the three teeth of the cutting edge equal in length, and with no indications of three grooves leading from the teeth to the molar surface, such as are distinctly seen in the South African specimens.

The maxilla (fig. 2, e) is smaller in comparison with that of the triungulin larva. In each, the cardo (cd.) is a triangular structure with a pair of lateral setae. It is fused with the stipes (st.) for only a short distance along its anterior border. The stipes is similar in both larvae, but in the cerambycoid larva the galea (gal.) is furnished with five stout spines and the lacinia (lac.) with ten ventral and seven dorsal spines. In Böving and Craighead's figure (1931) the galea has only four spines and the lacinia two rows of spines on the ventral

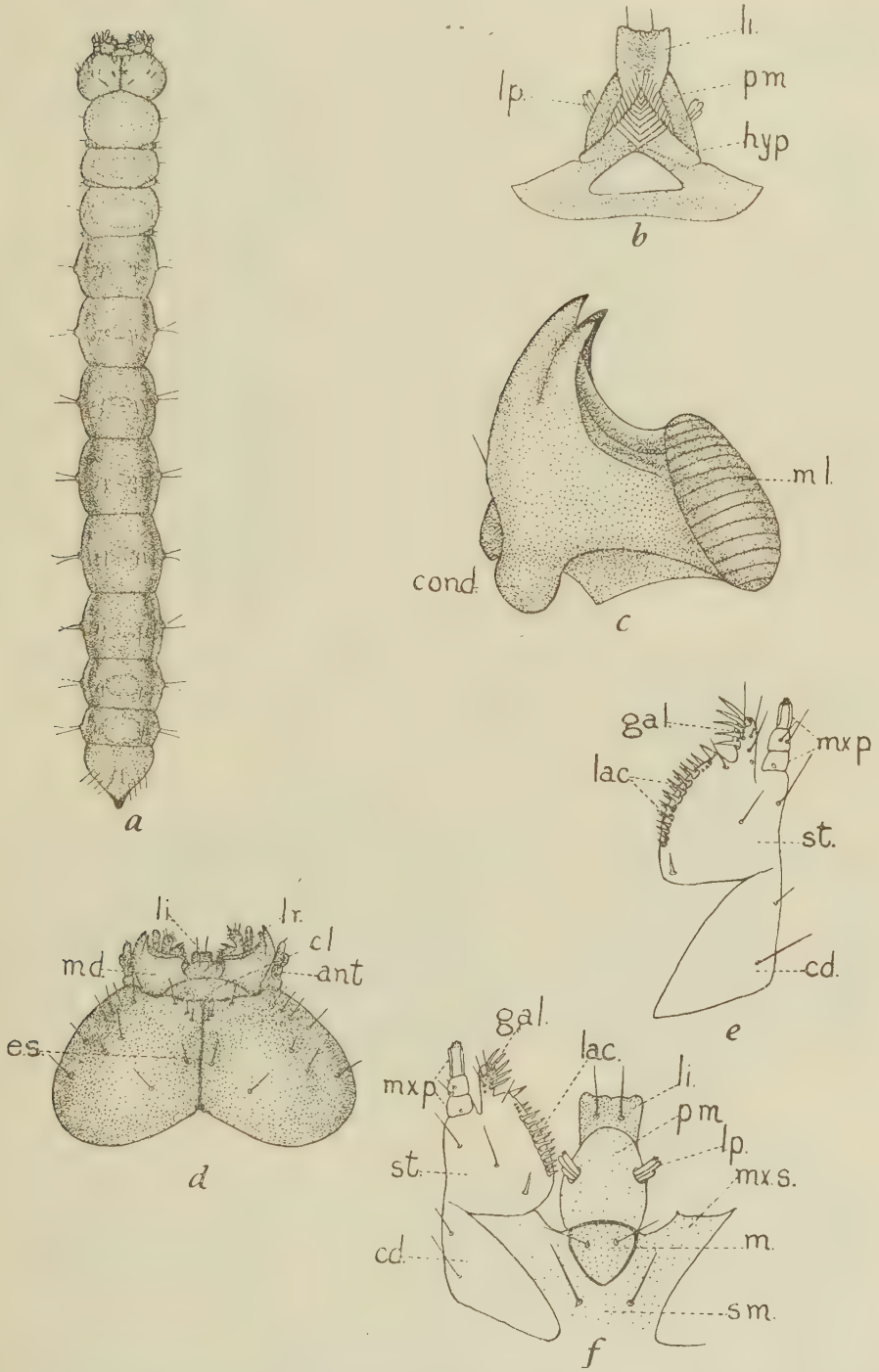


FIG. 2.—Cerambycoid larva of *Micromalthus*. *a*. cerambycoid larva, dorsal view; *b*. hypopharynx and ligula; *c*. right mandible, ventral view; *d*. head, dorsal view; *e*. left maxilla, ventral view; *f*. labium and right maxilla.

surface, and the lacinia is separated from the stipes as a definite sclerite, but this suture is not evident in the South African specimens. The palps (mx. p.) are similar to those of the triungulin larva.

Between the cardo and stipes of each maxilla is a membranous connection (mx. s., fig. 2, f) which Böving and Craighead (1931) term the maxillary articulating area. In the South African specimens, however, this area is not separated from the submentum (sm.) as is the case in the North American species. The submentum (sm.), which is not a distinct sclerite, bears two elongate setae. The mentum (m.) is separated from the prementum (pm.) by a distinct suture. The palps (l.p.) are similar to those of the triungulin larva, in that they are three-segmented. In Böving and Craighead's figure (1931), the palps are also three-segmented, but the segments are linear in arrangement.

The ligula (li., figs. 2 and 6) is similar to that of the triungulin larva and expands distally into a triangular hypopharynx (hyp., fig. 2, b). The latter is provided on the upper surface with numerous oblique serrations, which correspond to those of the molar areas of the mandibles, into which they lock when the mandibles are closed. This structure corresponds very closely with that of the North American specimens except that Böving and Craighead (1931) found the serrations to be confined to the hypopharynx, while in the South African specimens these serrations are continuous from the hypopharynx to the ligula.

Thorax.

The thoracic segments (fig. 2, a) are flattened dorsally but the sternites protrude slightly and act as pseudopods. The prothorax bears a pair of spiracles laterally towards the posterior margin of the segment. Unlike the triungulin larva, the cerambycoid larva is apodous.

Abdomen.

The abdomen consists of nine segments, of which the first eight are subequal and cylindrical, while the terminal one is dorso-ventrally compressed and more pointed posteriorly than in the triungulin larva. The first eight segments are each provided with small medial tergal and sternal plates. Each segment has a pair of lateral, horizontal expansions, bearing a median protuberance which is furnished with a pair of setae. Each of these segments is provided with a pair of spiracles, which are situated on the dorsal surface in the anterior half of the segment. Each spiracle has a circular, sclerotised peritreme, while that figured by Böving and Craighead (1931) is more or less oval in outline.

Morphology of the Paedogenetic Larva.

This larva (fig. 3, b) measures 3·5 mm. to 5 mm. in length, 1·5 mm. to 1·7 mm. across the thorax, and the width of the head is 1 mm. to 1·2 mm. The larva is white, cylindrical with an obvious black mass (th. m.) showing through the body-wall of the thoracic region (th.). The head is similar to that of the cerambycoid larva, except that it is smaller in comparison with the length of the body and its parts are more membranous.

The mouth parts are essentially similar to those of the cerambycoid larva, but they are reduced and non-functional. Ocelli are absent.

The prothorax, which has a pair of lateral spiracles, is slightly more sclerotised on the tergum than the meso- and meta-thoracic segments. On

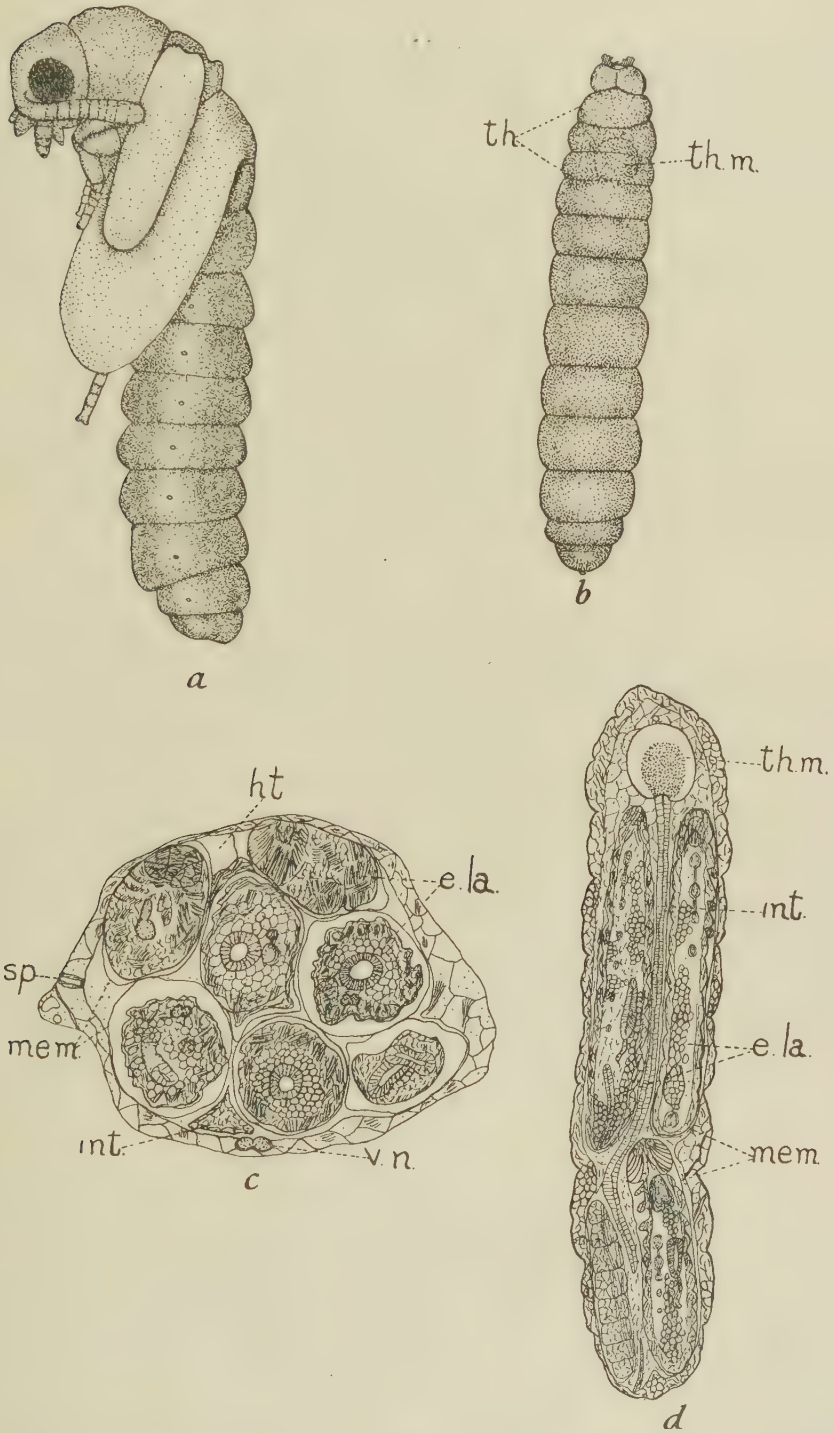


FIG. 3.—*Micromalthus*. *a*. pupa; *b*. paedogenetic larva, dorsal view; *c*. transverse section of the paedogenetic larva in the abdominal region; *d*. longitudinal section of the paedogenetic larva.

sectioning, the dark mass (th. m., fig. 3, d) located in the thorax was found to be the distended stomodaeum filled with food. From sections of both cerambycoid and paedogenetic larvae, it seems probable that prior to cessation of feeding in the former stage, the intestine becomes constricted at the posterior end of the stomodaeum. In this way a certain amount of food material remains stored up in the crop, while the rest of the intestine is voided of its contents. The intestine (int., fig. 3, d) continues throughout the length of the abdomen in the paedogenetic larva, but its walls have completely collapsed and its lumen is no longer evident. It is suggested that during development of the embryos the paedogenetic mother draws on this stored thoracic food mass for nourishment. In addition to the intestine, the heart (ht., fig. 3, c) and the ventral nerve cord (v.n.) are still present in the abdomen.

The abdomen itself is cylindrical to the seventh segment, while the last two are slightly narrower. The genital aperture lies on the ventral surface of the ninth or terminal segment. Each of the future triungulin larvae (e. la., figs. 3, c and 3, d) within the parent body is surrounded by a delicate membrane (mem., figs. 3, c and 3, d) and from observations on both transverse and longitudinal sections (figs. 3, c and 3, d) no definite arrangement of the larvae within the mother could be discerned.

Morphology of the Pupa.

The pupa (fig. 3, a) is white in colour and the thorax has a marked dorsal curvature. The head is ventrally directed and has an elevation dorsal to each eye. Each of the latter is large and the lower edge touches the antenna. The latter is eleven-segmented, backwardly directed, and terminates at about the middle of the costal margin of the elytron.

The thoracic segments are subequal and dorsally flexed. Each elytron is an elongate structure reaching to the second abdominal segment and partly overlying the wing. The wings, which are considerably longer than the elytra, reach to the fourth abdominal segment and are curved round to the ventral surface of the body. The pro- and meso-thoracic legs are sharply bent at the femoro-tibial joints, which are not apposed to the body but ventrally directed. The metathoracic legs are completely covered by the wings, except for the terminal tarsal segments which project from between the wing apices.

The abdomen is cylindrical to the seventh segment, while the last three taper slightly and are somewhat elevated. Each of the first nine segments is provided with a pair of spiracles which is situated on the pleural region.

Summary.

The life-cycle as worked out by Barber (1913) is summarised and Caillol's (1914) interpretation of the various stages are discussed. From my observations it is concluded that some of Caillol's modifications of the life-cycle are correct. In particular, his reasons for suggesting that the caraboid larva is comparable with the triungulin of such forms as the Meloidae seem to be borne out by the present work, and the term triungulin has, therefore, been substituted for Barber's caraboid stage. There seems, however, to be no reason for considering the paedogenetic larval stage as a neotenic female, as suggested by Caillol.

The discovery of *Micromalthus* in the mines of the Witwatersrand is the first

reported occurrence of this beetle outside North America. It seems probable that *Micromalthus* was introduced from America in infested timber, but it is possible that it is an indigenous South African species.

A large amount of infested timber was examined, and although adult females, paedogenetic, cerambycoid and triungulin larvae were found, no males or their larval predecessors were discovered. There is a remarkable difference in the rate of development of individual triungulin larvae produced by the same mother and reared under similar environmental conditions.

The cerambycoid larva undergoes three ecdyses before passing into the paedogenetic stage, but there is considerable variation in the length of the different instars.

Detailed accounts of the morphology of the triungulin, third cerambycoid, paedogenetic larvae and pupa are given.

Tabular Summary of Differences between South African and American Specimens.

	South African Specimens.	American Specimens.
A. *Triungulin larva.*	Epicranial suture not forked anteriorly.	Epicranial suture forked anteriorly.
B. *Cerambycoid larva*:		
(1) Antenna.	(*a*) 4th segment lateral.	(*a*) 4th segment medial.
	(*b*) Terminal spine relatively short.	(*b*) Terminal spine more elongate.
(2) Mandible.	Median tooth longer than two lateral. Each tooth is grooved to the molar area.	All three teeth subequal in length. No grooves.
(3) Maxilla.	(*a*) Galea with five strong spines, lacinia with ten ventral and seven dorsal spines.	(*a*) Galea with four spines, lacinia with two ventral rows of spines.
	(*b*) Maxillary articulating area not distinguishable from submentum.	(*b*) Maxillary articulating area distinctly separated from submentum.
(4) Labium.	Segments of labial palps in juxtaposition.	Segments of labial palps linear.
(5) Hypopharynx.	Sclerotised serrations continuous from ligula to hypopharynx.	Serrations confined to the hypopharynx.
(6) Spiracles.	Peritreme circular.	Peritreme oval.
C. *Adult female.*	Ten abdominal segments.	Nine abdominal segments.
D. *Habitat.*	Moisture essential for the welfare of the larvae.	Larvae apparently able to thrive in dry wood.

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I wish to express my deep appreciation to Professor C. J. van der Horst and Dr. N. F. Paterson for their guidance and assistance in the preparation of this work. I am indebted to the following for material which they have collected and forwarded to me at the University: Miss R. Lurie, University of the Witwatersrand; the Manager of the Timber Exchange Yard, Johannesburg; the Manager and members of the staff of the East Rand Proprietary, Springs and Robinson Deep Mines. I wish also to thank Dr. K. G. Blair of the British

Museum (Natural History), London, for the identification of specimens of *Micromalthus debilis* LeC. I am indebted to Mr. W. Paff, University of the Witwatersrand, for the photograph of the infested timber.

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Key to the Lettering of the Figures.

ant.	antenna.	mem.	membrane surrounding the embryonic triungulin larvae.
cd.	cardo.	ml.	molar surface of the mandible.
cl.	clypeus.	m. pm.	mentum and prementum fused.
cla.	terminal claw of the leg.	mx. p.	maxillary palp.
cond.	condyle of the mandible.	mx.s.	maxillary articulating area.
cx.	coxa.	p.m.	prementum.
e. la.	embryonic triungulin larvae.	sm.	submentum.
e.s.	epicranial suture.	sp.	spiracles.
fe.	femur.	st.	stipes.
gal.	galea.	ta.	tarsus.
ht.	heart.	th.	thorax.
hyp.	hypopharynx.	thm.	thoracic mass.
int.	intestine.	ti.	tibia.
lac.	lacinia.	tr.	trochanter.
li.	ligula.	v.n.	ventral nerve cord.
l.p.	labial palp.	1, 2, 3, 4.	first, second, third and fourth antennal segments.
lr.	labrum.		
m.	mentum.		
md.	mandible.		

Explanation of Plate 1.

Timber of *Pinus* sp. showing a burrow excavated by the larvae of *Micromalthus*.

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Timber of *Pinus* sp. showing burrow of *Micromalthus* larva.

NOTE ON THE EXTERNAL MORPHOLOGY OF SOUTH AFRICAN SPECIMENS OF *MICROMALTHUS* (COLEOPTERA)

By Nellie F. Paterson, Ph.D., M.Sc.

During the past few years certain observations have been carried out on the occurrence of *Micromalthus* in the timbers used in the underground workings of the gold mines on the Witwatersrand. While all stages of larvae were abundant, adults were rarely seen and, so far, only a few females have been collected.

During the course of the study it became apparent that there were certain marked differences between the South African specimens and those described by LeConte (1878) as *Micromalthus debilis*. As there was some doubt as to the identity of the South African specimens, some American *M. debilis* were sent to me through the kindness of Dr. K. G. Blair, of the British Museum, for comparison with the South African forms.

A careful study of the two, leads me to conclude that the South African forms belong to the same species as the American, but, in addition to certain morphological differences between the two, there are also certain statements in LeConte's description of *M. debilis* that are not applicable to the American specimens submitted to me by Dr. Blair.

The South African specimens are slightly longer than the American, measuring 2·5 mm.–2·8 mm. long by 0·5 mm. broad.

The antennae (fig. 4, f) are 11-segmented in both forms, and in neither are they as long as the combined lengths of the head and prothorax. In both forms they appear to reach only a short distance beyond the anterior margin of the prothorax. The mouth parts (figs. 4, f and 4, h) are prognathous, and although not described by LeConte, they seem to be essentially similar in both forms.

In the South African specimens the elytra (fig. 4, a–d) reach only to the second abdominal segment, whereas in the American specimens they extend at least one segment farther back. Judging by Hubbard's figure (1878) of the American form, the elytra are approximately half the total length of the body, but in the South African specimens they measure $\frac{7}{19}$ of the body length.

One rather remarkable feature is the presence in some South African *Micromalthus* of seven free abdominal segments (fig. 4, b–d), while in the American forms six only are clearly visible. This, however, cannot be regarded as a constant feature of South African specimens, for in some, while seven tergites were observed, only six sternites were visible, the sixth being the largest and almost completely obscuring the reduced seventh.

While LeConte's description applies in general to both the American and South African specimens herein compared, it is noteworthy that as one of the characters of *M. debilis* he mentioned the absence of tibial spurs. Both the American and South African specimens examined by me possess quite strongly developed spurs, two occurring on each anterior tibia (fig. 4, g, ts.), and one on the middle and posterior tibiae. According to LeConte's description slight differences are to be noted in the direction of the coxae of the three pairs of legs, and the anterior pair is stated to be contiguous. In the South African *Micromalthus* the coxae articulate laterally with the thoracic segments: all three pairs are similarly directed, and those on the prothorax are just as widely

separated as are those on the meso- and meta-thorax. Examination of the specimens sent from the British Museum shows a similar arrangement and separation of the anterior coxae in American forms.

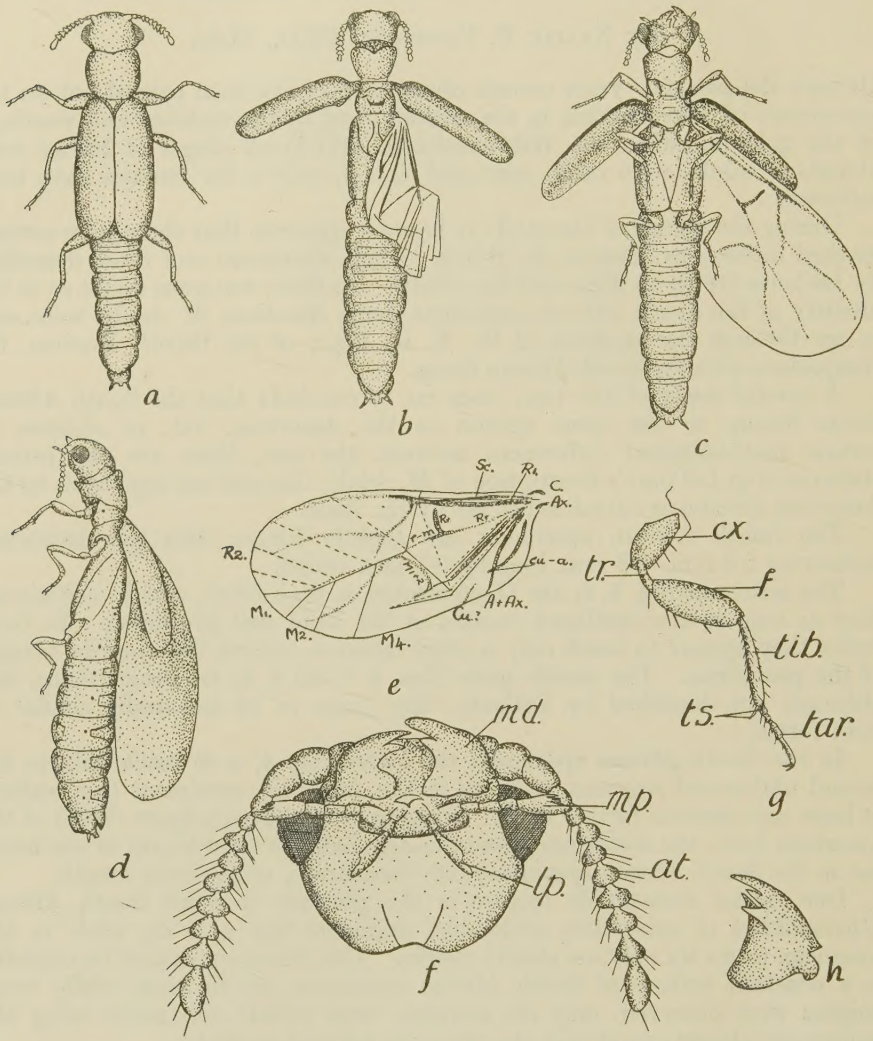

FIG. 4.—a–d. Views of *Micromalthus* female; e. wing of *Micromalthus*, showing venation and folding; convex folds are indicated by continuous lines and concave folds by broken lines; f. ventral view of head; g. prothoracic leg; h. mandible.
at., antennae; lp., labial palp; md., mandible; mp., maxillary palp; cx., coxa; tar., tarsus; tib., tibia; tr., trochanter; ts., tibial spurs; f., femur.

d'Orchymont (1921) and Kempers (1923) have indicated the importance of the study of the wing venation in the Coleoptera, especially if, as d'Orchymont has shown, the folding of the wing is taken into consideration. The venation of South African *Micromalthus* is essentially similar to that described for

American *M. debilis* by van Emden (1932), but in the South African forms there are faint traces of several veins (R_2., M_1., Cu. ?, cu-a., fig. 4, e) not figured by van Emden.

The venation is chiefly remarkable for its reduction, a fact which makes the interpretation of the homologies of the veins a matter of some difficulty. d'Orchymont, who recognised two main types of wing venation in Coleoptera, the Adephagid and Polyphagid, showed that in the former the median cell is transversely directed and oblong in shape, whereas in the Polyphagid type it is a longitudinally placed triangular cell. A further constant criterion established by d'Orchymont is the position of the two main longitudinal folds of the wing with reference to the radial and medial veins, and the intersection of the transverse r-m vein by both of these folds.

When these facts are applied to the wing of *Micromalthus* (fig. 4, e) it is found that the longitudinal folding is of little assistance in elucidating the homologies of its reduced venation. In addition to the anal fold there are two other longitudinal folds, one between the subcosta and the radius and the other immediately above the medius, neither of which falls across the r-m transverse vein. When, however, the folding is compared with that of the Adephagid, *Cupes*, figured by d'Orchymont, a similarity between them is noticed immediately in two somewhat transversely-directed folds. In *Cupes* these two folds are continuations of the two main longitudinal folds, but in *Micromalthus* the longitudinal direction of the uppermost seems to have been lost. These folds fall across a vein, which must be interpreted as the r-m transverse vein, as in *Cupes*.

The " oblongum " (medial cell) is no longer a closed cell in *Micromalthus*. It distal wall has disappeared, but its proximal wall, formed by M_{1+2} is quite strongly developed.

van Emden (1932) has remarked that the cubitus is absent. In South African specimens there is a faint trace of a vein at the margin of the wing, which might be interpreted as part of the otherwise reduced cubitus (Cu. ?, fig. 4, e). The anal and axillary veins strongly recall those of *Hydrochus* figured by d'Orchymont (1921), but Kempers' figure of the wing of *Hydrochus carinatus* Germ. (fig. 264) differs considerably. It would seem, however, that in this region the venation approximates more closely to the Polyphagid type. In *Micromalthus* the anal cell is open, owing to the absence of the transverse vein, but, as in *Hydrochus*, a small portion of the cu-a vein is apparent.

While the interpretation of the reduced venation is decidedly of importance, the chief interest attaching thereto is that its arrangement is a further indication of the Adephagid affinities of this species. van Emden (1932) has already discussed this in his study of the wing venation, and it also seems to be the conclusion arrived at by other systematists from a consideration of other morphological features (Böving and Craighead, 1931; Meixner, 1935).

From the foregoing observations it is concluded that, although they differ in certain respects from the American specimens of *Micromalthus debilis* LeC., there is not sufficient evidence for creating a new species for South African forms of *Micromalthus*. Certain factors, such as their peculiar environment wherein they are subjected to practically the same conditions all the year round, may have contributed towards these changes, and have led to slight variations, which from cursory examination might appear to have unwarranted significance.

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